Background paper 1:

Evidence of ammonia effects on the environment at low ambient concentrations

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NATURAL ENVIRONMENT RESEARCH COUNCIL

Background

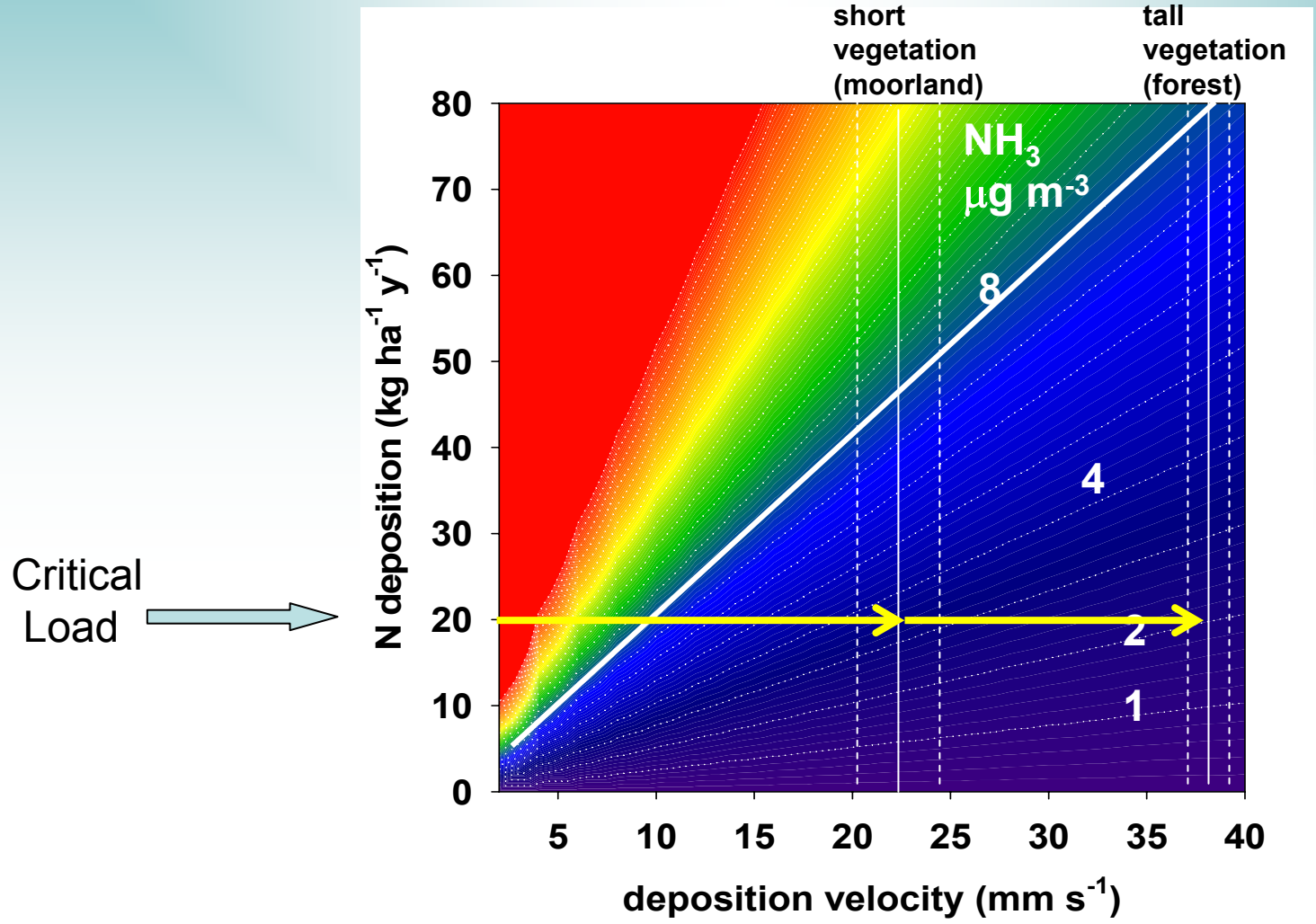
- **Historical Critical Levels – annual 8 μg NH_3 m^{-3}**

Critical Level: "the concentrations of pollutants in the atmosphere *above which* direct adverse effects on receptors, plants, ecosystems or materials, may occur according to present knowledge."

- **Relationship to Critical Loads**

Critical Load: "the deposition limit *below which* effects do not occur according to present knowledge."

What does the current annual Critical Level achieve as a protective measure?



- **The Critical Load protects ecosystems from the effects of NH_3 more effectively than the current Critical Level….**
  - **even if there are no other sources of N deposition**

But does the Critical Load provide adequate protection at NH_3 concentrations which are less than the Critical Level?

The issue:

Is there evidence of effects at concentrations less than the current Critical Level?

"…nearly all of the information (*used to calculate critical levels)* originating from one Dutch research group. Only a few pollution climates were considered." WHO (1997)

"In the Netherlands, for example, all cyanobacterial lichens that were present at the end of the 19th century are now absent. In Denmark, 96% of the lichens with cyanobacteria are extinct or threatened."
WHO (1997)

The evidence:

- **From controlled experiments conducted at low background concentrations**
- **From point sources of NH_3 where air concentrations have been monitored**

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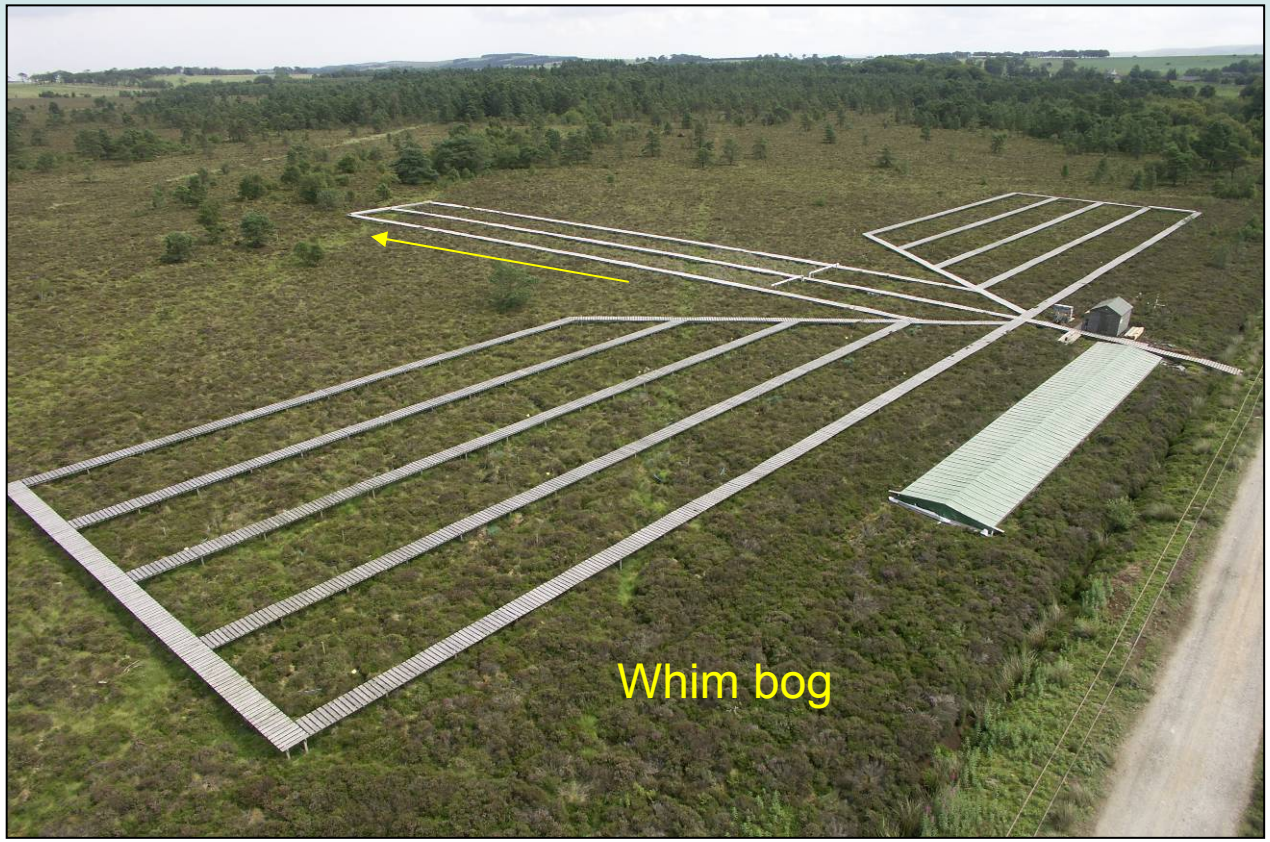
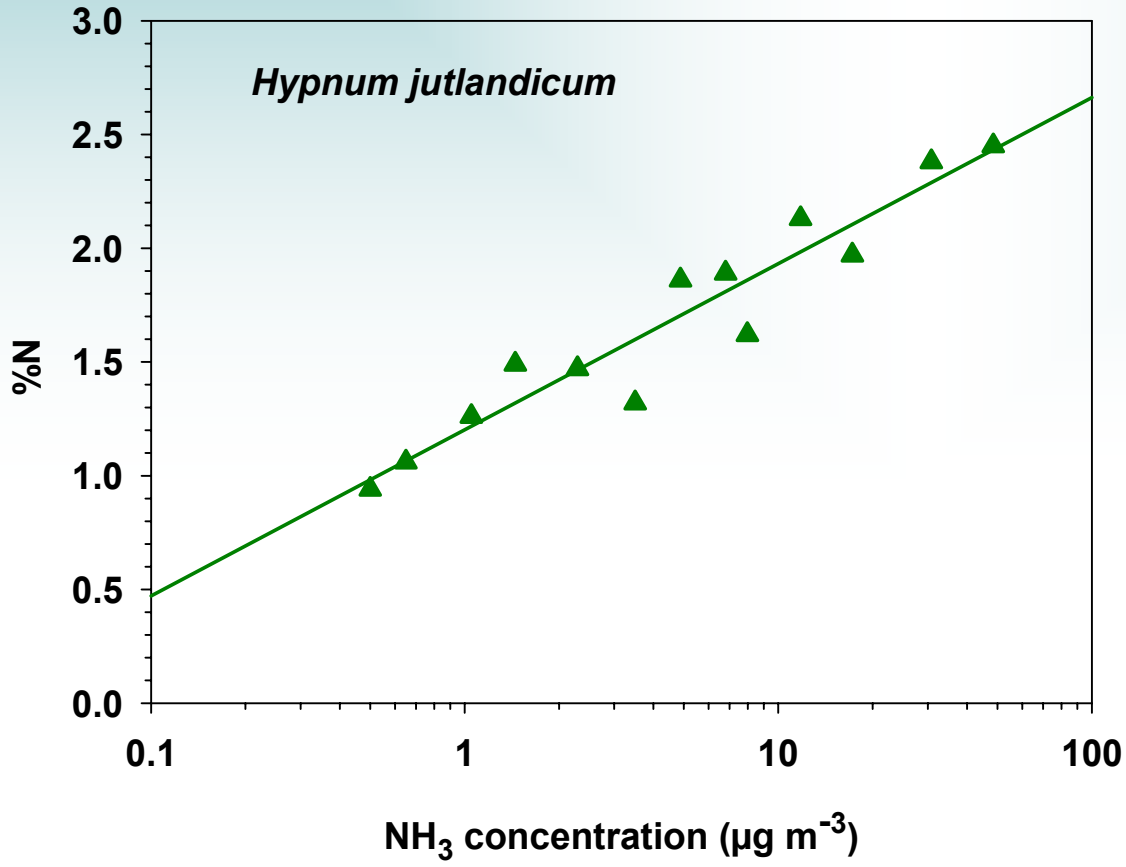


The evidence:
Whim bog – N content of a moss



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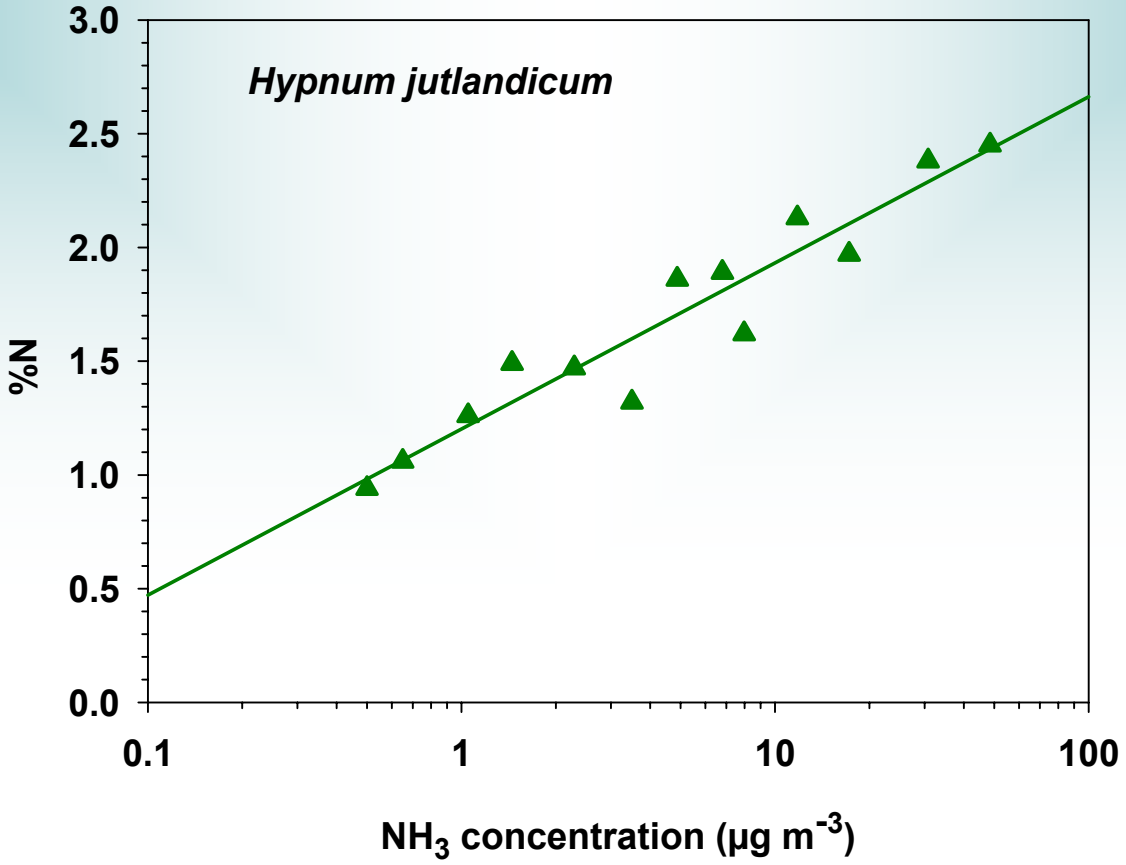
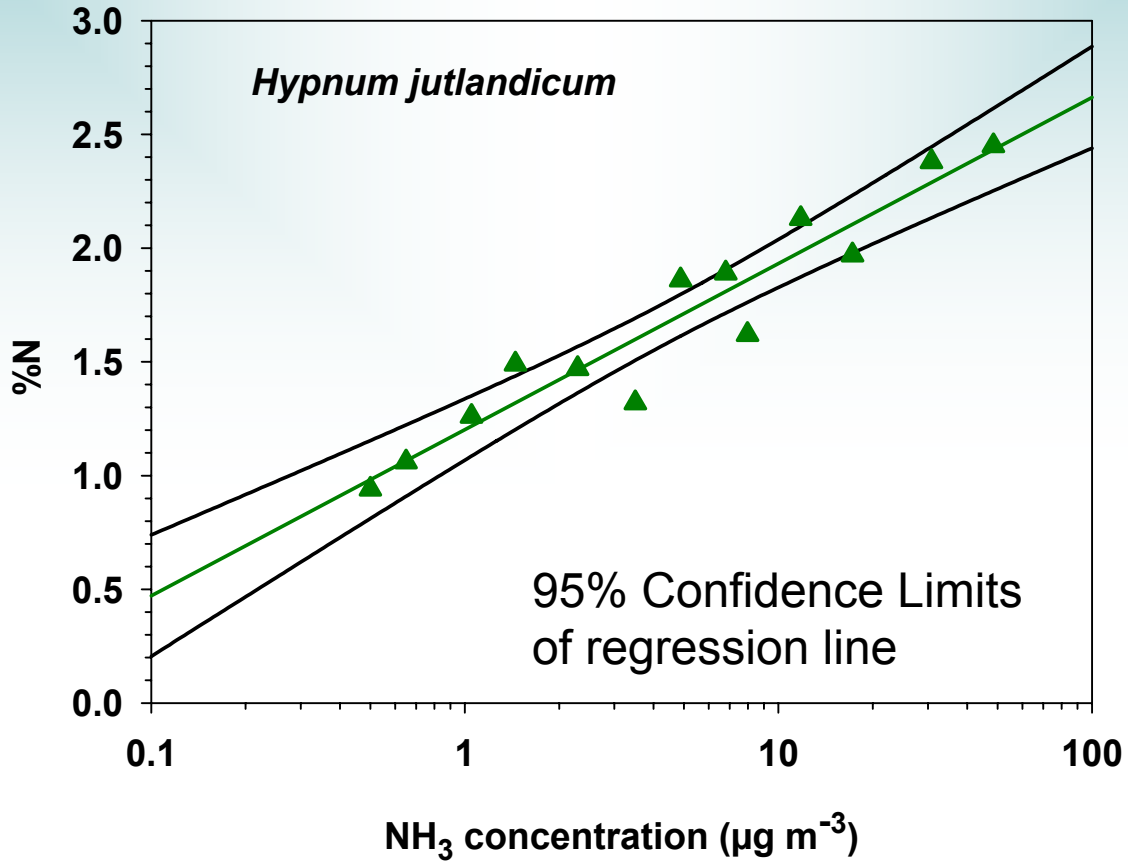


At what NH_3 concentration is there a significant effect of NH_3?

The evidence:
Whim bog – N content of a moss



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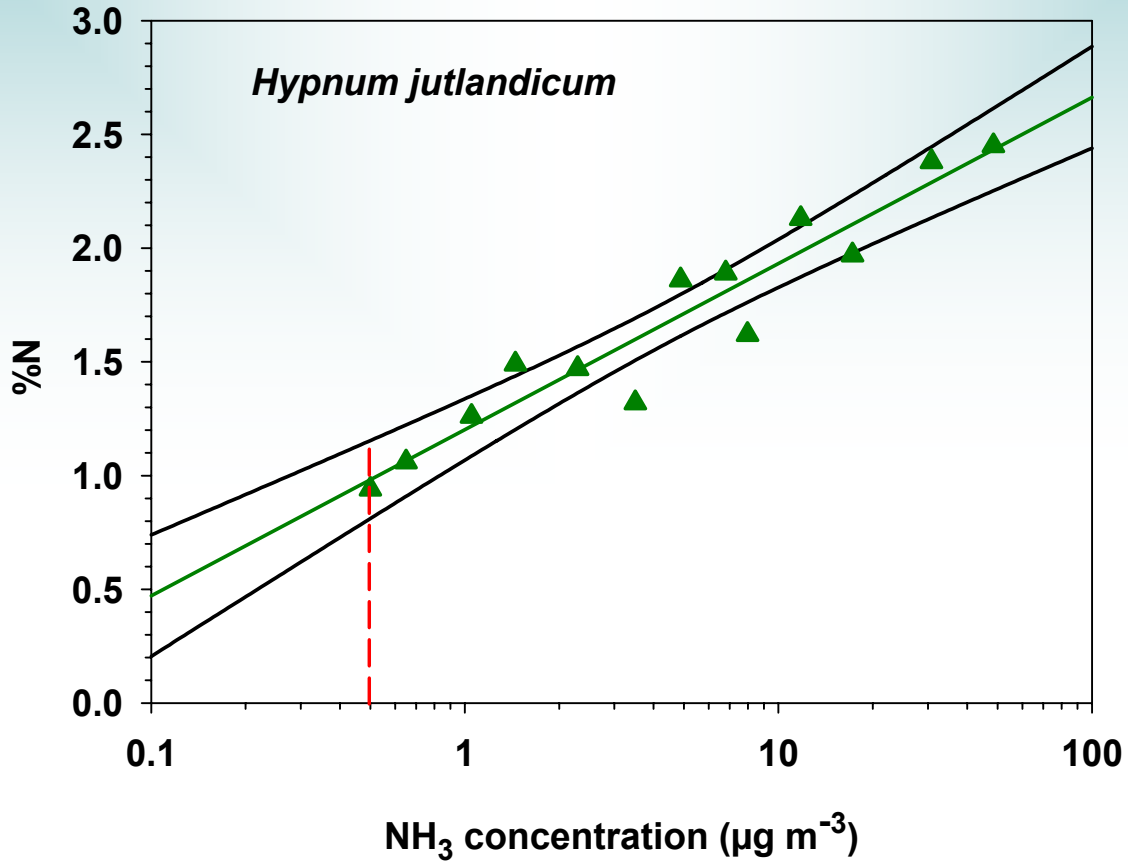

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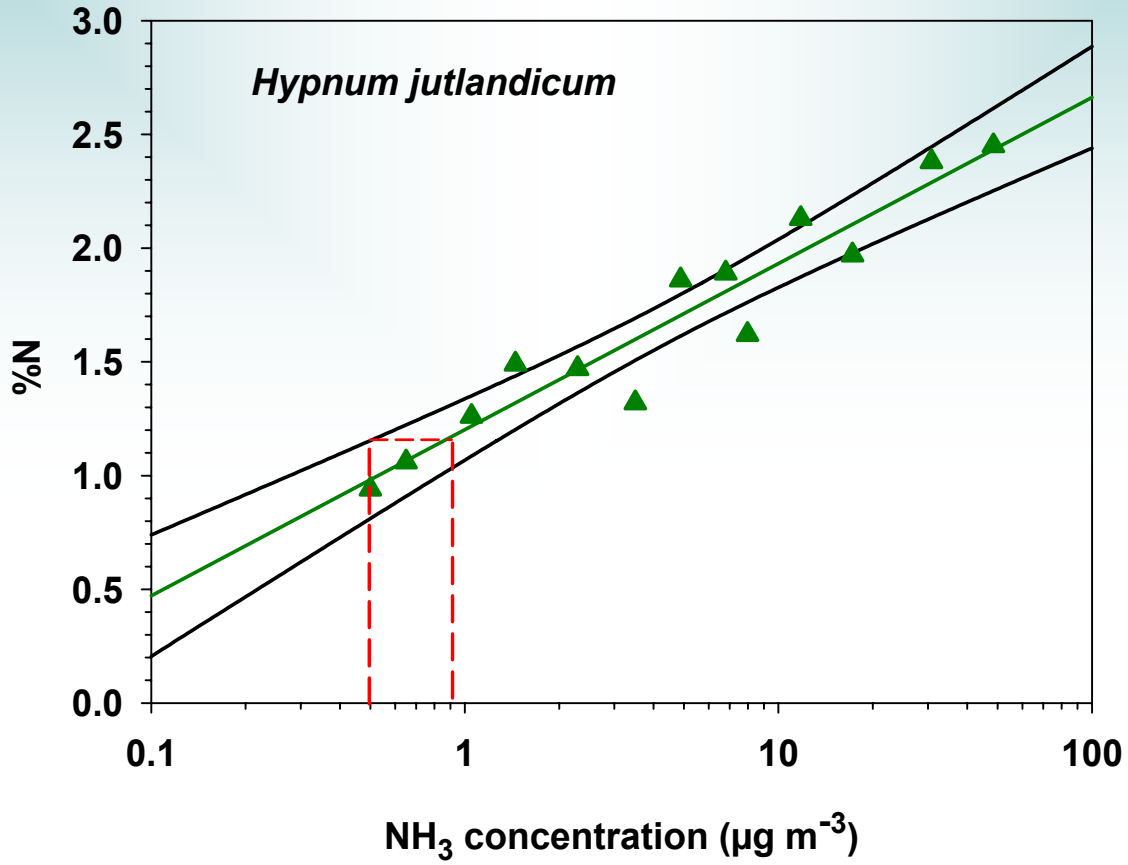

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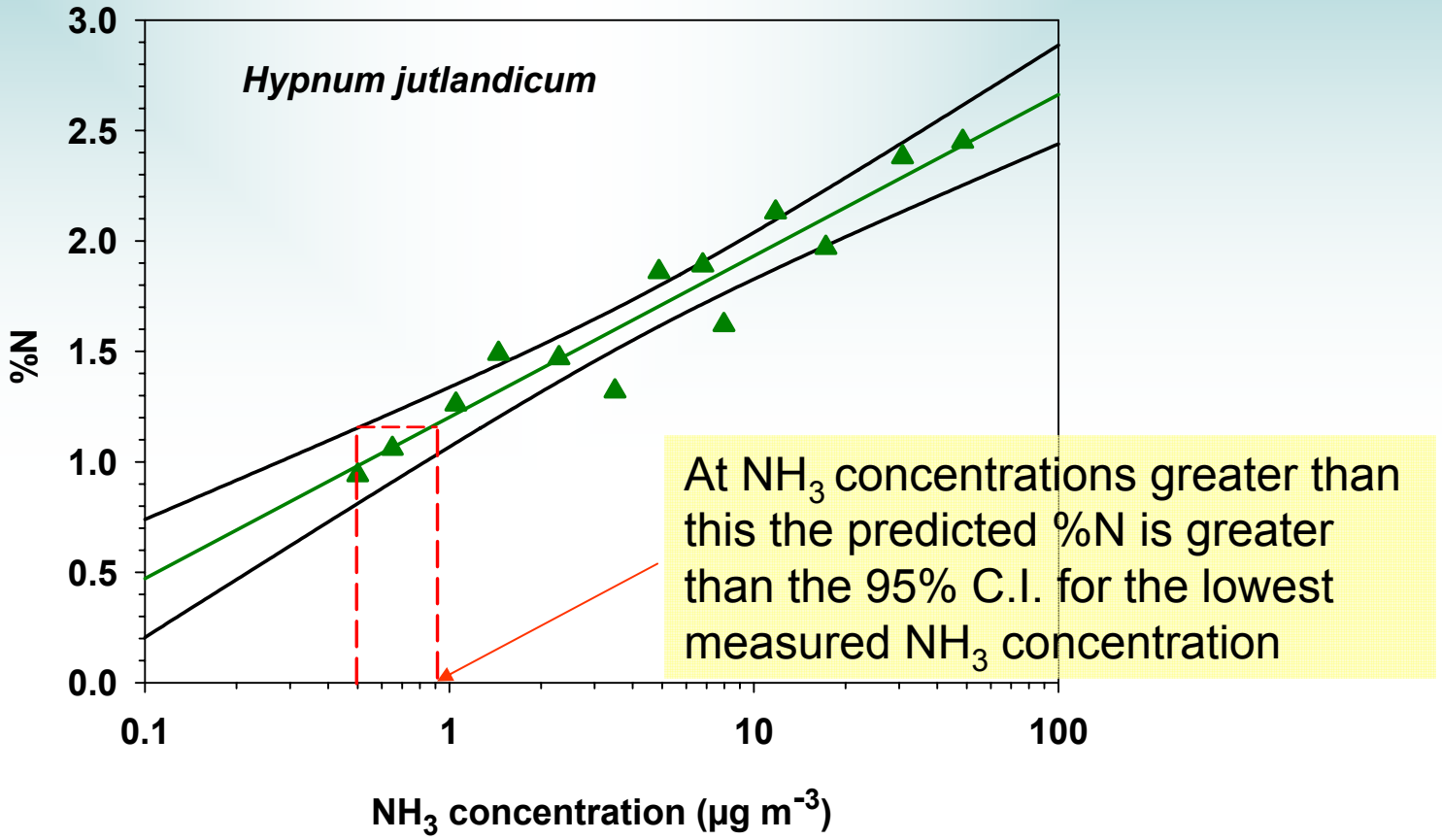
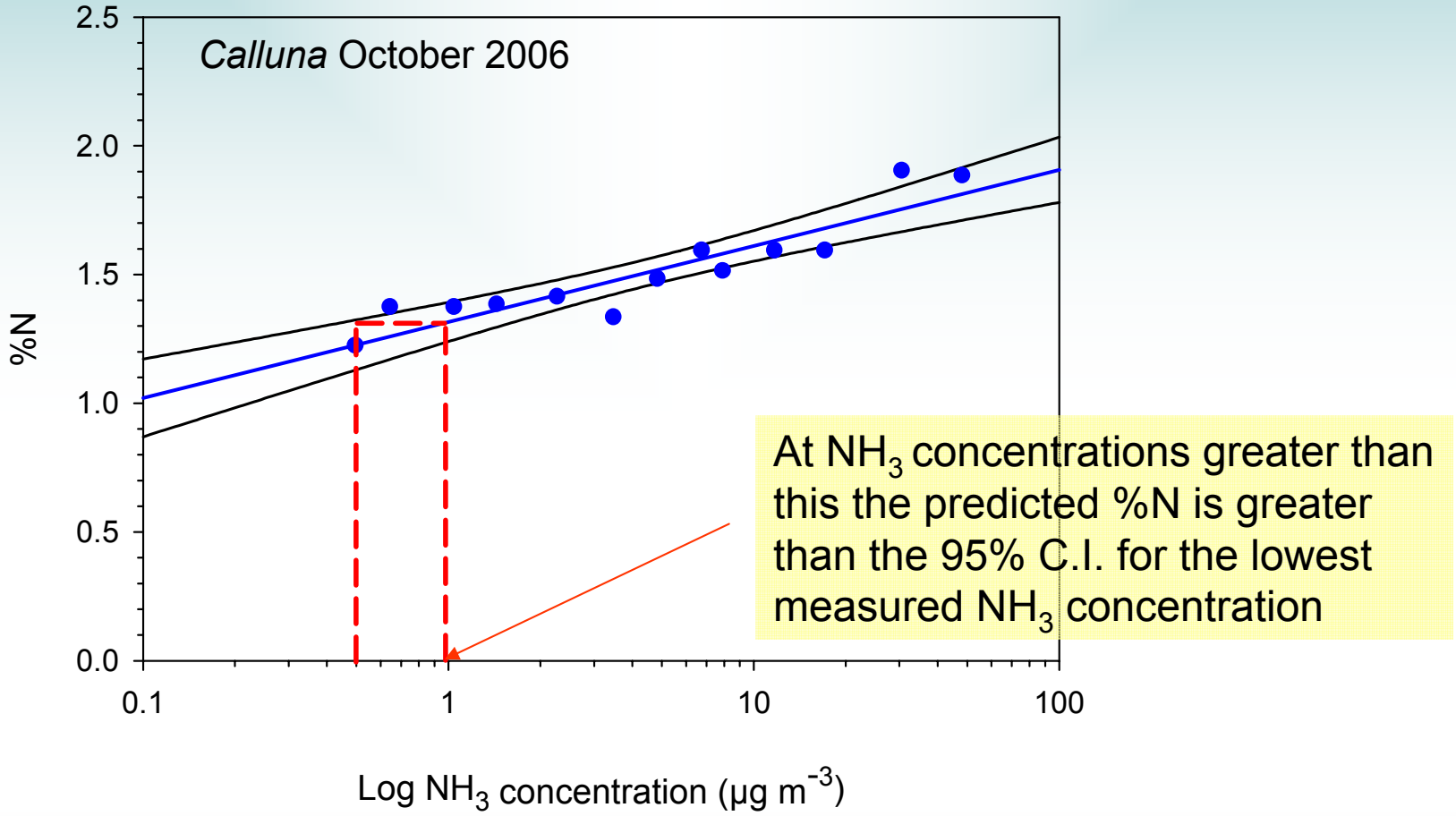
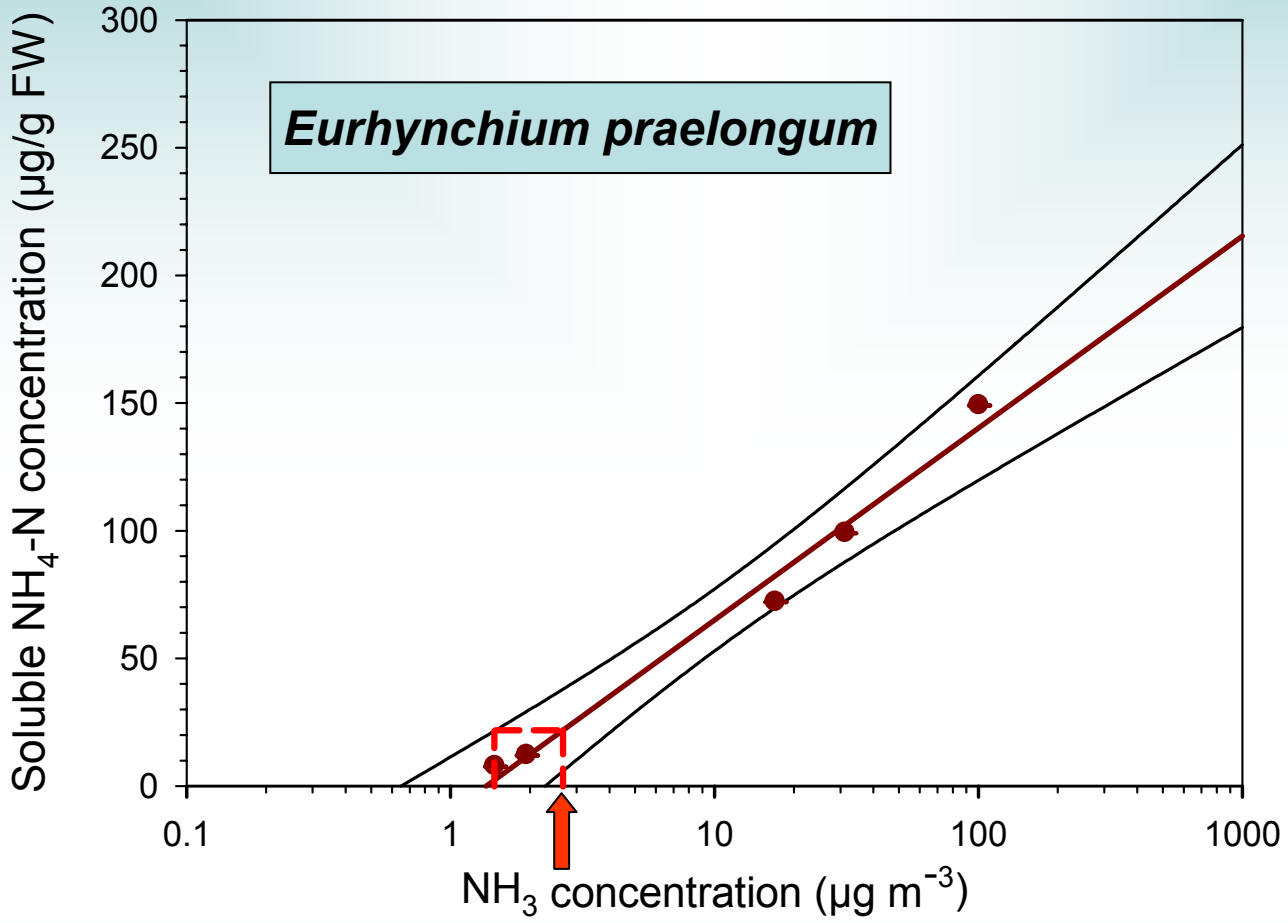


The evidence:
Whim bog – N content of heather (*Calluna vulgaris*)



The evidence:
Downwind of a poultry farm, S.W. England
Soluble ammonium (NH_4-N) in moss



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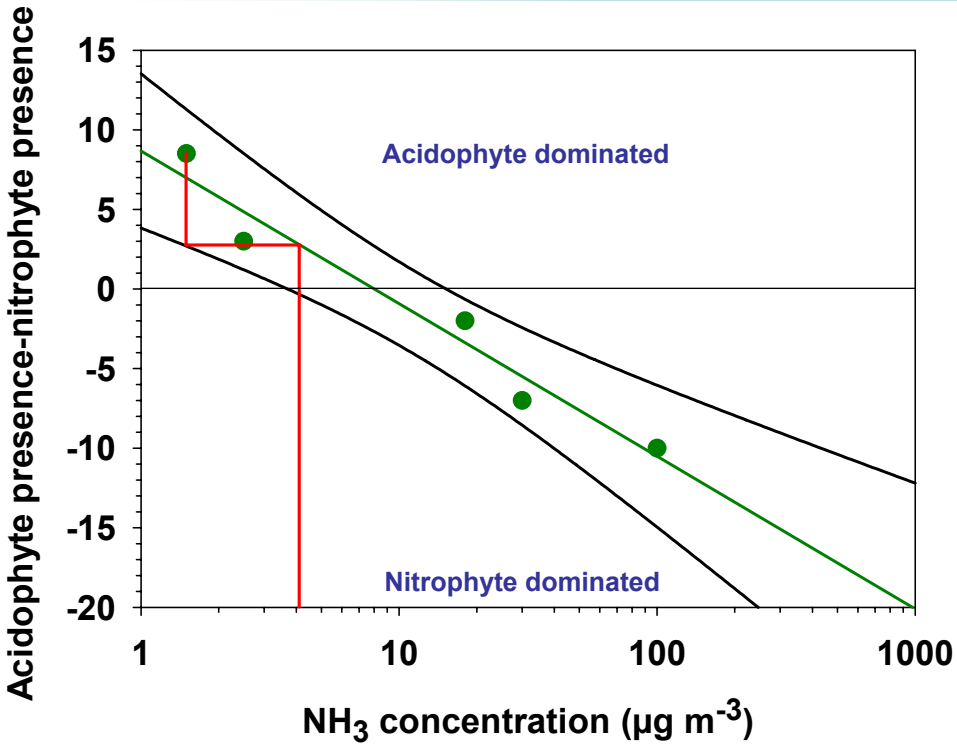
Ammonia reduces the abundance of woodland flowers

Wood sorrel (*Oxalis acetosella*)

is replaced by:



Velvet grass (*Holcus lanatus*)

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The evidence: Lichen Acidophyte-Nitrophyte Index

Acidophytes

Bryoria spp.
"Trolls Beard"

Hypogymnia spp.

Usnea spp .

Nitrophytes

Xanthoria spp.

Physcia spp.

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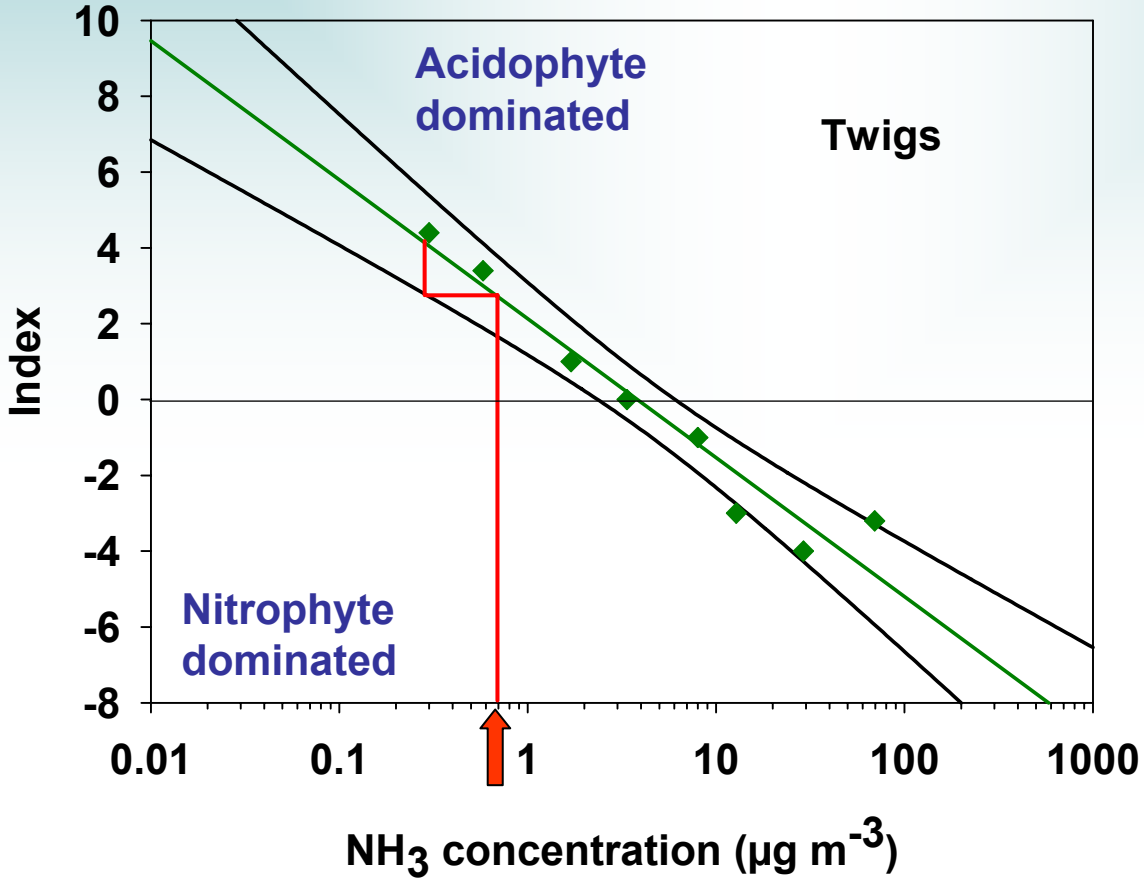
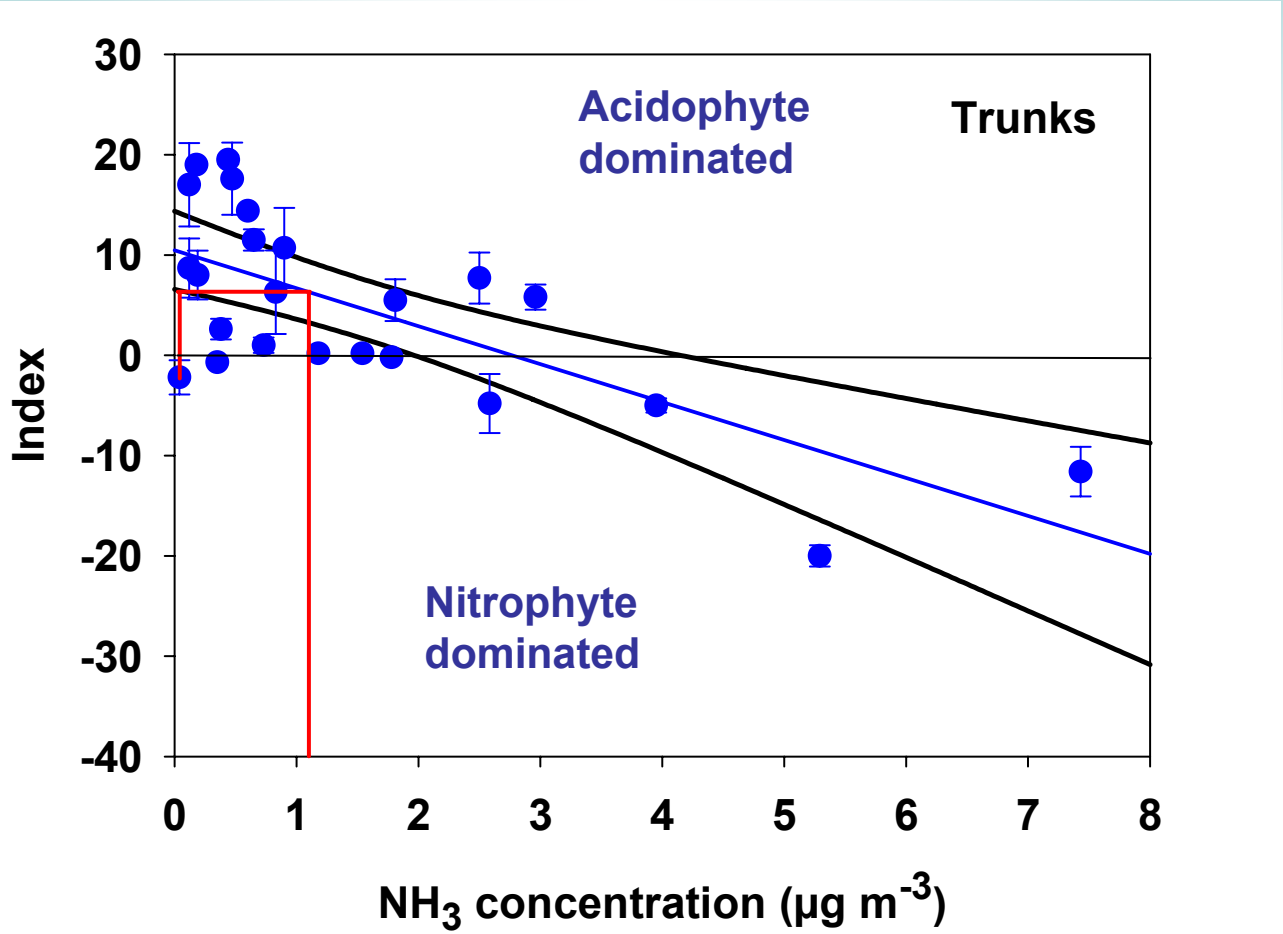
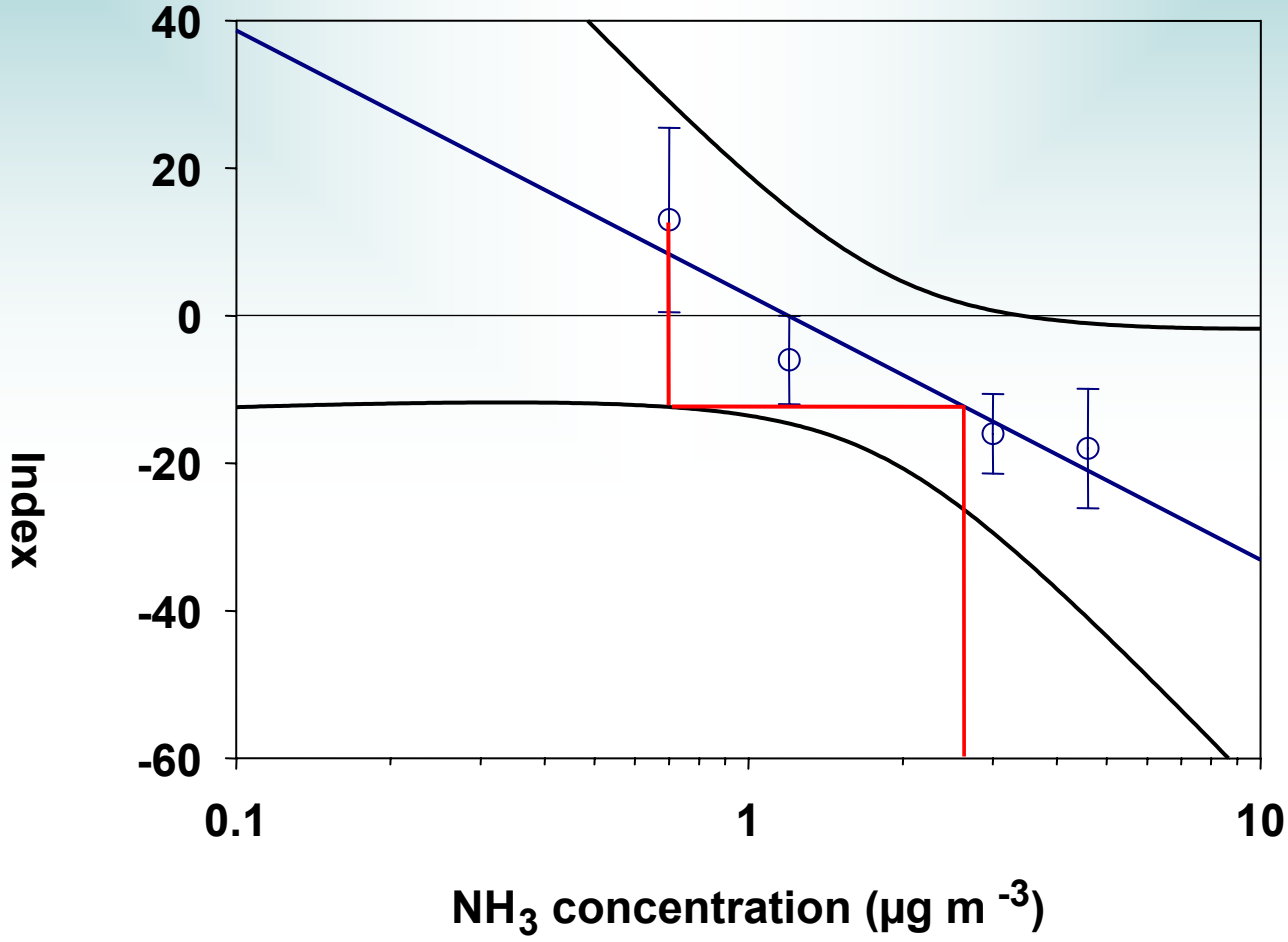
The evidence:
Downwind of poultry farm, S.E. Scotland
Lichen acidophyte-nitrophyte index



The evidence:
Lichen acidophyte-nitrophyte index
UK lichen survey, 2006



The evidence:
Downwind of a pig farm, Italy (Frati *et al*. 2006)
Lichen: acidophyte-nitrophyte index

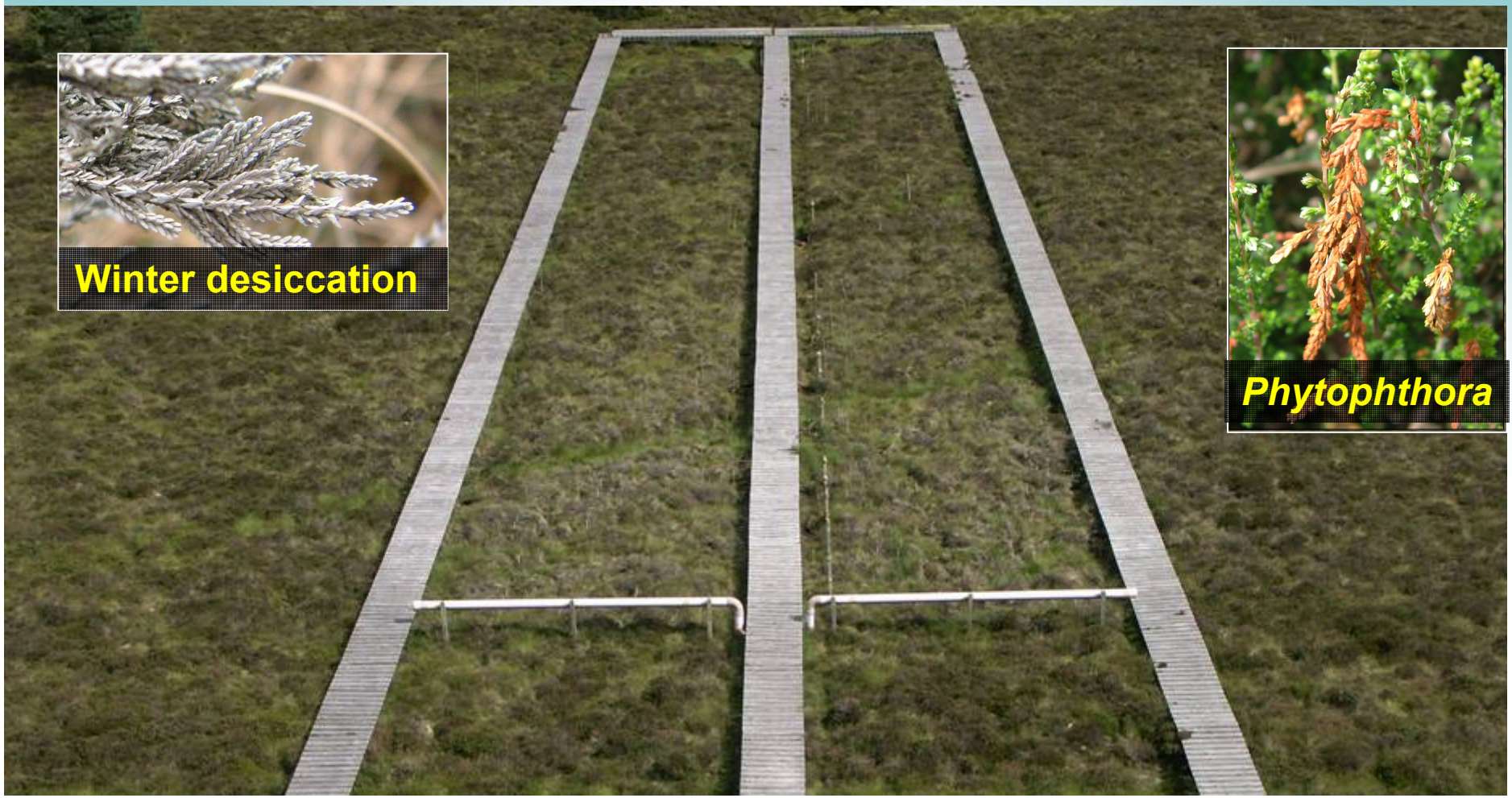


Summary of evidence

Ammonia concentrations above which changes are measurable

N content of moss	S.E.Scotland	0.9 μg m^{-3}
N content of heather	S.E.Scotland	1.0 μg m^{-3}
arginine in moss	S.W.England	2.2 μg m^{-3}
NH_4^+ in moss	S.W.England	2.8 μg m^{-3}
Woodland groundflora	S.W.England	4.2 μg m^{-3}
Lichen A-N index	S.E.Scotland	0.7 μg m^{-3}
Lichen A-N index	UK survey	1.1 μg m^{-3}
N content of lichen	Italy	2.0 μg m^{-3}
Lichen A-N index	Italy	<2.6 μg m^{-3}
$\delta^{15}N$ content of lichen	Namibia	0.05 μg m^{-3}

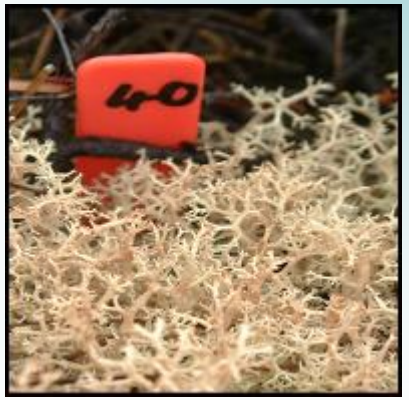
Does the Critical Level need to be set for longer than one year?



Does the Critical Level need to be set for longer than one year?

Progressive damage to lichen *Cladonia portentosa* at Whim Bog

Pre-treatment March 2002



May 2002

November 2002

September 2003

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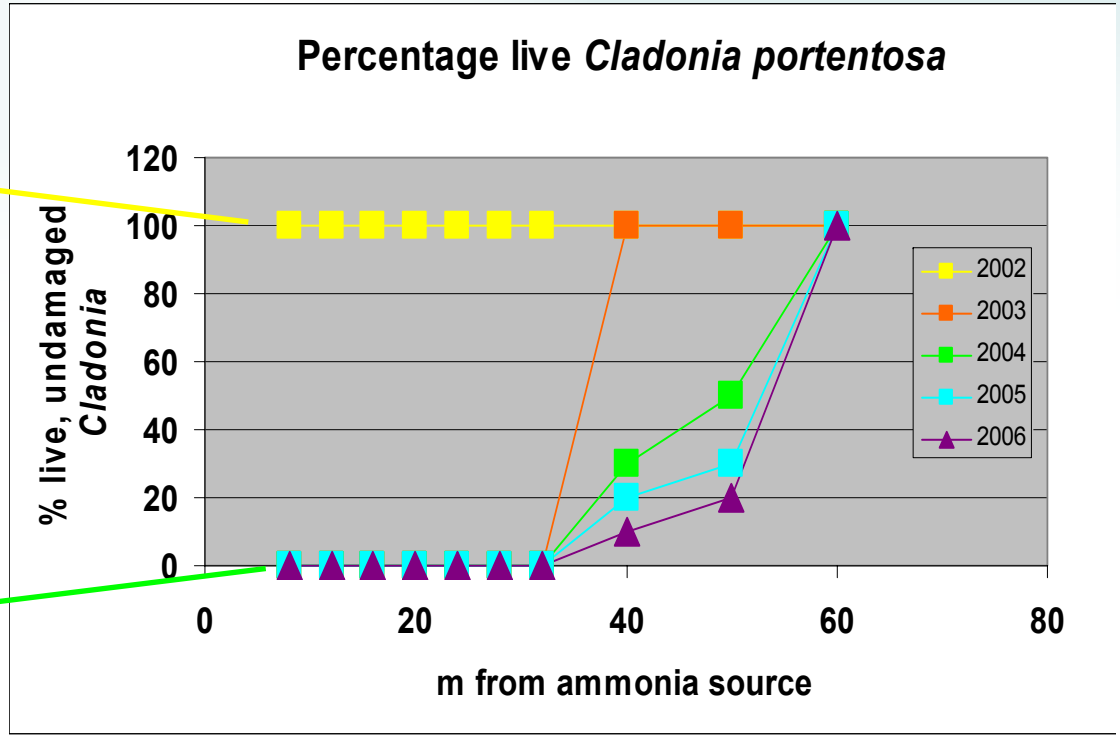
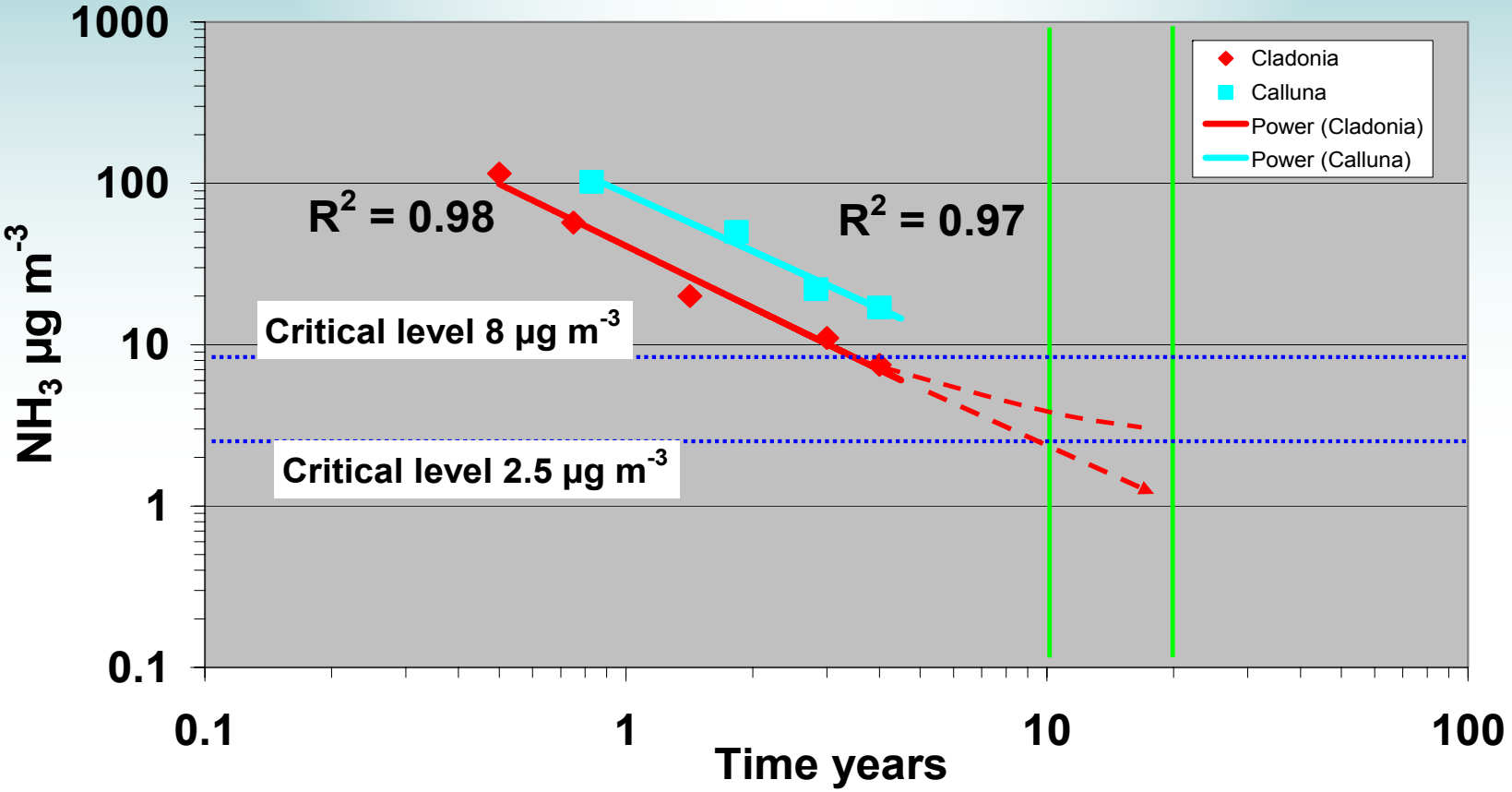


Does the Critical Level need to be set for longer than one year?

Ammonia concentration causing the death of *Cladonia portentosa* and > 85% death of *Calluna vulgaris* over time



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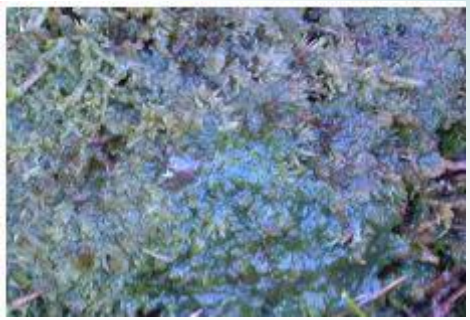
Questions for the working group

- **Is the concept of a Critical Level for NH_3 useful, given existing Critical Loads?**
- **How do we set the 'no effect' limit when considering experimental results?**
- **Do we have enough knowledge to set specific Critical Levels for different regions, climates and sensitive habitats?**
- **Do we need to have a 'many year' Critical Level to match the time scale of effects?**

Practical applications of a new Critical Level

- **Protects the most sensitive components of an ecosystem (where they still exist)**

Healthy *Sphagnum capillifolium*
Whim Bog



NH_3 damaged *Sphagnum capillifolium*
Whim Bog

Healthy *Polytrichum commune*
Whim Bog

NH_3 damaged *Polytrichum commune*
Whim Bog

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Alpha sampler

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Thank you to all my colleagues – and to you for listening

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